NSB 03-151

FULFILLING THE PROMISE

A REPORT TO CONGRESS ON THE BUDGETARY AND PROGRAMMATIC EXPANSION OF THE NATIONAL SCIENCE FOUNDATION

National Science Board
December 4, 2003

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CONTENTS

Executive Summary

This report responds to Section 22 of the National Science Foundation Authorization Act of 2002 (P.L. 107-368), which directs the National Science Board (NSB) to prepare a report to address the Foundation's budgetary and programmatic growth provided for by the Act.

Last year Congress overwhelmingly passed the NSF Authorization Act of 2002, which authorized a path toward doubling the NSF budget over five years, to a total of nearly $10 billion by FY 2007. It is a meaningful initial step towards realizing the full potential of the science and engineering (S&E) enabled by NSF. In this report, the Board analyzed the full extent of the research and education needs that are not being met and determined the NSF budget must be increased to nearly $19 billion to fully address them. *The intent is to bring the federal investment in basic research and education to a level that will sustain future U.S. leadership in science and technology.*

There has never been a more critical or opportune time to invest in research and education. Researchers are on the verge of new frontiers where the integration of vast computing power, massive data sets, large complex models, and new analytical tools will enable them to understand, simulate, and predict the behavior of the most complex social, biological and environmental systems. This new knowledge promises to remake the way people live, work, and interact. But exploiting this new knowledge requires a U.S. S&E workforce - researchers, educators, technologists, and skilled workers – that can tackle increasingly complex and radically different tasks. More U.S. students must be attracted to S&E fields, and provided with high quality education and training and access to the most advanced tools, facilities, and cyberinfrastructure. If we fail to do this, increasing numbers of high technology and manufacturing jobs will go overseas.

Among federal agencies, NSF has a unique role in supporting academic research and education. As noted in the Act: "NSF has made major contributions for more than 50 years to strengthen and sustain the nation's academic research enterprise that is the envy of the world." Indeed, ideas first conceived in the laboratories of NSF-funded researchers have underpinned new technologies, led to multi-billion dollar industries, helped create new jobs and benefited countless lives. Fiber optics, radar, wireless communication, nanotechnology, plant genomics, magnetic resonance imaging, ultrasound, and even the Internet could not have occurred without underlying knowledge from NSF-supported work in the basic sciences and engineering. Moreover, this work has shed light on the most profound questions about the origin and nature of the universe, the planet, and human life. NSF has supported the work of 123 Nobel laureates, including five this past year. While advancing the frontiers of knowledge, NSF simultaneously strengthens and builds the future S&E workforce. Each year NSF supports more than 200,000 people – teachers, students, and researchers - many of whom go into industry and help create new technologies, products, jobs and company start-ups.

The Authorization Act increases NSF's annual budget by $4.3 billion, from $5.5 billion requested in FY 2004 to $9.8 billion authorized in FY 2007. In developing the following recommendations on how this increased funding should be used, the Board addressed a

limited number of unmet needs, rather than spread increases across all of the Foundation's programs, to ensure the most productive use of the funding.

The National Science Board recommends the following increases in funding:

- **$1.0 billion to improve the productivity of researchers and expand opportunities for students.** The average size and duration of research grants will be increased so that thousands of the nation's top researchers can pursue more complex and innovative research while spending less time preparing proposals.

- **$1.0 billion to open new frontiers in research and education.** This will enable scientists and engineers to explore emerging research frontiers and pursue novel ideas and research approaches with the potential to transform S&E fields.

- **$0.7 billion to help build a diverse, competitive and globally engaged U.S. S&E workforce.** NSF's student and postdoctoral programs will be enhanced, as well as successful K-12 programs, support for international collaboration, and cutting-edge research on workforce dynamics, learning and teaching.

- **$0.2 billion to increase the number and diversity of institutions that participate in NSF-funded activities.** Institutions that are successful in attracting, retaining and graduating U.S. students from under-represented groups will be identified and supported. Increased support will also be provided to faculty and students at smaller universities and colleges for research and professional development activities.

- **$1.2 billion to provide scientists and engineers with advanced tools, facilities, and cyberinfrastructure.** This will support the full range of next generation infrastructure needed to advance research frontiers and sustain U.S. S&E leadership.

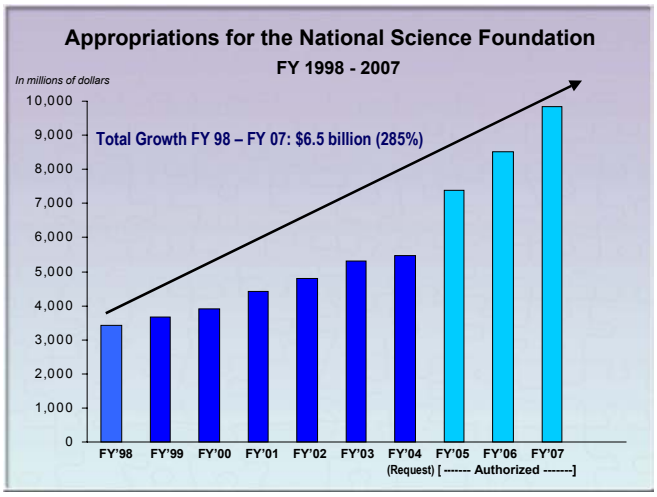
- **$0.2 billion to maintain NSF's excellence in management.** The NSF workforce and management infrastructure will be strengthened through new technology and leading-edge management approaches. This will maintain the efficiency, effectiveness and excellence of NSF's research and education programs.

Each of the recommended areas builds and reinforces NSF's strengths. It is precisely this connectivity and synergy that the Board values most. It is the reason why NSF is one of the most successful agencies for promoting scientific progress and sustaining the U.S. S&E leadership. Nothing is as important to our nation's future as the ability to create and make use of knowledge. This depends on the quality of the nation's research and education enterprise and the S&E workforce and infrastructure that sustain it. Using its hallmark strategy of integrating merit-based research and education, NSF can build the future workforce and cutting-edge infrastructure and simultaneously advance the frontiers of knowledge. But to ensure the nation's future S&E leadership and economic competitiveness, it is critically important to make the needed investment in research and education *now*, while there are still spectacular opportunities for success.

This report responds to Section 22 of the National Science Foundation Authorization Act of 2002 (P.L. 107-368), which directs the National Science Board (NSB) to prepare a report to address and examine the Foundation's budgetary and programmatic growth provided for by the Act. The Act further directed the NSB to submit the report to the Congress by December 22, 2003.

I. INTRODUCTION

Last year Congress recognized the vital role that science and engineering plays in society by overwhelmingly passing the National Science Foundation Authorization Act of 2002 (P.L. 107-368). This legislation authorized a path toward doubling the NSF budget over five years, to a total of nearly $10 billion by FY 2007. (See Appendix A for table of specific amounts authorized.)



As noted in the Authorization Act: "The National Science Foundation has made major contributions for more than 50 years to strengthen and sustain the nation's academic research enterprise that is the envy of the world." Indeed, NSF's impact over the last fifty years has been nothing short of monumental. Ideas first conceived in the laboratories of NSF-funded researchers have underpinned new technologies, led to multi-billion dollar industries, helped create new jobs and benefited countless lives. Fiber optics, radar, wireless communication, magnetic resonance imaging, ultrasound, and even the Internet could not have occurred without underlying knowledge from NSF-supported work in the basic sciences and engineering. NSF fundamental research has also proven critical to address the security challenges facing the nation. Even the geographic information systems used to coordinate efforts at the World Trade Center were based on NSF supported research.

Alan Greenspan, in his Congressional testimony, pointed out that "70% of the growth of the American gross domestic product, since World War II, can be directly attributed to the exploitation of new technologies." An NSF-supported study found that 70 percent of the scientific papers cited in U.S. industry patents came from science supported by public funds and performed at universities, government labs, and other public agencies.[1] Five of this year's eight Nobel Laureates in Physics, Chemistry, and Economics have received NSF funding during their careers. This year's awards bring to 123 the number of Nobel laureates funded by the National Science Foundation - 41 in physics, 33 in chemistry, 22 in physiology and medicine, and 27 in economics.

[1] Francis Narin, Kimberly S. Hamilton, and Dominic Olivastro, "The Increasing Linkage Between U.S. Technology and Public Science," *Research Policy* 26, No. 3 (December 1997): 317-30.

NSF has also played a vital role in developing a U.S. science and engineering (S&E) workforce that is second to none. Each year NSF supports more than 200,000 people – teachers, students, and researchers - many of whom go into industry and help create new technologies, products, jobs and company start-ups.

There has never been a more critical or opportune time to invest in research and education. Researchers are on the verge of new frontiers where the integration of vast computing power, massive data sets (for example, genomic databanks), large complex models, and new analytical tools will enable them to understand, simulate, and predict the behavior of the most complex social, biological and environmental systems. This new knowledge promises to remake the way people live, work, and interact.

But exploiting this new knowledge requires a U.S. S&E workforce – researchers, educators, technologists, and skilled workers – that can tackle increasingly complex and radically different tasks. A Commerce Department study concludes that in less than two decades 60 percent of the nation's jobs will require technical skills possessed by only 22 percent of today's workers.[2] Clearly, we must attract more U.S. students to S&E fields, and provide them with high quality education and training and access to the most advanced tools, facilities, and cyberinfrastructure. If we fail to do this, increasing numbers of high technology and manufacturing jobs will go overseas.

II. UNMET NEEDS AND UNEXPLORED FRONTIERS

Section 22 of the Authorization Act requests the Board to provide recommendations on how the increased funding provided by the Act should be used, and to address several specific budgetary and programmatic issues (see Appendix B for the full text of Section 22). These recommendations are presented in Section III of this report.

Before developing its recommendations the Board analyzed the full extent of the research and education needs that are not being met and determined the NSF budget must be increased to nearly $19 billion to fully address them. *The intent is to bring the federal investment in basic research and education to a level that will sustain future U.S. leadership in science and technology.*

The priorities described below address what is needed, in the Board's view, to realize the full capacity and potential of the S&E community served by NSF.[3] Addressing these needs would require an estimated additional $13 billion, bringing the total NSF annual budget to nearly $19 billion. This additional funding is needed immediately but the Board recognizes that current budget pressures require that it be addressed over several years. In determining the full extent of these needs, the Board relied upon several recent Board reports (listed in Appendix C) that resulted from long-term and comprehensive studies.

[2] *Technology in the National Interest*, Department of Commerce, Office of Technology Policy, 1996.
[3] Items A, C, D and E address specific issues raised in Section 22 of the Act.

A. Improve the productivity of researchers and expand opportunities for students.

The Board believes that *increasing the average NSF research award size and duration* should be one of the highest priorities for increased NSF investment. Larger and longer awards will attract more students to S&E careers and increase the productivity and efficiency of researchers, who will spend less time preparing proposals and more time pursuing innovative ideas. This is a very cost-effective approach that will result in superior performance by the research community.

The recent survey of NSF-funded principal investigators and institutions[4] revealed a general consensus among principal investigators that average award size should be increased to about $250,000 per year and average award duration to about five years.[5] In the survey, over half of the respondents indicated that increasing award size and duration would allow them to pursue the innovative and high risk research ideas that they have been stymied from following due to constantly preparing for the next round of short term funding.

The survey also provided strong evidence that an increase in award size will allow researchers to employ more students in the research process, better preparing them for the S&E workforce. According to the survey, 81 percent of respondents indicated that they likely would use the increased funding to support graduate students. Support for undergraduates and post-docs were the next two most frequently cited areas. It is expected that increasing the award size will lead to increased stipends for graduate students working on research projects, eventually achieving parity with stipends provided by NSF fellowship and traineeship programs.

In FY 2004, NSF will provide about $2.7 billion to support research grants. NSF estimates that it will require an additional $6 billion per year to increase the average grant size from $128K (FY 2004 request) to $250K and the average grant duration from three to five years. This is still well below the average size of an NIH research award (R01), which is over $325K[6].

B. Open new frontiers in research and education.

The Board believes that the NSF should invest an additional $2 billion per year to take full advantage of unprecedented opportunities to open new research and education frontiers, explore novel research approaches, and develop new innovative technologies.

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[4] Mathematica Policy Research, Inc., July 2002

[5] Within these averages, there is a wide distribution of award sizes and durations based upon the type of research being conducted.

[6] http://grants1.nih.gov/grants/award/resgr.htm

NSF currently funds less than one in four new research proposals. Each year NSF must decline 1,500 to 2,000 meritorious research proposals due to the shortage of funding. For example, during FY 2003, nearly $1.5 billion was requested for declined proposals that had received reviewer ratings as good as those being funded. These declined proposals – currently a waste of tremendous S&E talent - are a rich portfolio of unfunded opportunities to explore the S&E frontier.

Since FY 1990 NSF's Small Grants for Exploratory Research (SGER) mechanism has enabled program officers throughout the Foundation to make small-scale grants to support preliminary work on untested and novel ideas, application of new approaches, and ventures into emerging research areas. In FY 2002, NSF made 278 SGER awards for $16.7 million, far below what is really needed. The lack of funds to support worthy proposals, as noted above, also suppresses the support of SGER grants. In view of the importance of these grants to respond quickly to new opportunities, the Board recommends that support for SGER awards be significantly expanded.

Increased funding is also needed to initiate investment in new strategic, community-driven, frontier activities, giving emphasis to programs that transcend intellectual and organizational boundaries, stress integration of research and education, or initiate new partnerships with other agencies or international entities. The investment should be made through a centrally-managed Innovation Fund. In the past, the Foundation has used such a fund to explore new and emerging science questions, test instrumentation and process designs, and seed novel ways to engage U.S. citizens in science and engineering.

Additional funding should also be used support new priority research areas and increase existing areas to optimum levels. The FY 2004 Budget Request requests $773 million to support six priority areas -- Biocomplexity in the Environment, Information Technology Research, Nanoscale Science and Engineering, Mathematical Sciences, Human and Social Dynamics, and Workforce for the 21st Century. FY 2004 is the last year for specifying Information Technology Research, funded at $303 million, as a priority area. Much of the funding identified for ITR will continue within the base for similar activities. In a recent report[7], the Board recommended that support for environmental research, education, and scientific assessment at NSF be increased by an additional $1 billion, phased in over the next 5 years, to reach an annual expenditure of approximately $1.6 billion. NSF funding is still far below this target. Other priority research areas that are underfunded include Nanoscale Science and Engineering, Mathematical Sciences, and Human and Social Dynamics.

As previously noted, increasing the average size and duration of NSF grants will also enable researchers to pursue more innovative and high risk ideas and tackle increasingly complex and radically different problems.

[7] *Environmental Science and Engineering for the 21st Century: The Role of the National Science Foundation*, Feb. 2000, NSB 00-22

C. Build a diverse, competitive and globally-engaged S&E workforce.

The NSF Authorization Act includes a number of policy objectives for NSF to increase overall workforce skills and strengthen the Nation's lead in science and technology, including expanding the U.S. pool of scientists and engineers. Through the Authorization Act, NSF will also be better positioned to respond to the National Policy Imperative as stated in the recent report[8] by the National Science Board's *Task Force on National Workforce Policies for Science and Engineering (NWP)*; namely:

> *The Federal Government and its agencies must step forward to ensure the adequacy of the U.S. science and engineering workforce. All stakeholders must mobilize and initiate efforts that increase the number of U.S. citizens pursuing science and engineering studies and careers.*

The NWP report further observed that the future strength of the U.S. S&E workforce is imperiled by two long-term trends:

> *Global competition for S&E talent is intensifying, such that the U.S. may not be able to rely on the international S&E labor market to fill unmet skill needs;*
>
> *The number of native-born S&E graduates entering the workforce is likely to decline unless the Nation intervenes to improve success in educating S&E students from all demographic groups, especially those that have been underrepresented in S&E careers.*

In light of this new report, the Board believes that NSF current efforts to build the future S&E workforce must be expanded – and with a heightened sense of urgency. At least $2 billion - in addition to current funding of $1.1 billion - is needed to fully address the following S&E workforce goals:

- Prepare scientists, mathematicians, engineers, technologists and educators capable of meeting the challenges of the 21st Century;
- Attract and retain more U.S. students to science and engineering fields; and
- Increase international collaboration in S&E research and education.

Some particularly urgent needs include the following:

- Enhance NSF's undergraduate, graduate and postdoctoral programs. Both the numbers of students supported and the amount of support per student (i.e., stipends) must be increased.

- Expand support for programs that are particularly effective in attracting U.S.

[8] *The Science and Engineering Workforce - Realizing America's Potential*, August 14, 2003, NSB 03-69

talent to S&E fields, especially those that tap into underrepresented groups. For example, institutions involved in the Louis Stokes Alliances for Minority Participation (LSAMP) program produce 70 percent of the underrepresented minority science and engineering baccalaureate degree recipients.

- Support the President's education initiative, the Math and Science Partnership (MSP), at the level authorized by Congress. Through MSP, substantially more U.S. regions will be able to dramatically improve their K-12 science and mathematics education.

- Promote international collaborative activities. The dynamics of science and engineering increasingly demand international collaboration; for example, development and construction of the next generation of major observational research facilities will require substantial international partnering. In a recent report[9] the NSB Task Force on International Issues in Science and Engineering recommended that the U.S. government facilitate international collaboration in S&E research and education, particularly by younger scientists and engineers and with developing countries The Board believes that the Foundation, with its unique S&E workforce role and its reputation for political neutrality, should be an innovative leader in promoting international cooperation.

- Support additional research that enhances understanding of learning and teaching at the K-12 and undergraduate level. Additional research is also needed to determine what experiences, strategies, or practices are most effective in attracting and retaining students in careers that require fluency in mathematics, science, engineering, or technology.

- To support development of effective S&E workforce policies and strategies, NSF should substantially increase its investment in research on workforce dynamics; and lead a national effort to build a base of information on the current status of the S&E workforce, national S&E skill needs, and strategies that attract high-ability students and professionals to S&E careers.

D. Increase the number and diversity of institutions of higher education that participate in NSF-funded activities.

The Board believes that NSF should give priority to investments that tap into the potential in previously underrepresented groups and institutions of the Nation's human resource pool. This strategy is vital to maintaining a strong, robust and balanced science and engineering enterprise and developing a competitive 21st century S&E workforce.

While NSF is currently supporting a number of effective strategies, such as the Experimental Program to Stimulate Competitive Research (EPSCoR) and the Advanced

[9] *Toward a More Effective Role for the U.S. Government in International Science and Engineering*, NSB 02-01

Technological Education (ATE) program, the Board believes that additional funding of $500 million is needed to support the following strategies:

- Expand cyberinfrastructure to increase access to research and education resources, so that every institution of higher education has access to state-of the-art S&E facilities, tools, databases, digital libraries, and other infrastructure.

- Develop a new program for institutions that will identify best practices in attracting, sustaining, retaining, and graduating U.S. students from under-represented groups, and invest in those institutions that demonstrate this skill so they can enhance their performance.

- Increase the number of schools that participate in the Robert Noyce Scholarship program. This program provides funds to institutions of higher education to support scholarships, stipends, and programs for students who commit to teaching in high-need K-12 schools.

- Enable faculty and students at smaller universities and colleges to work in summer positions at NSF supported multi-user research facilities and participate in other professional development activities.

- Provide start-up awards for new Ph.D.s (out less than 5 years). Most Ph.D.s wish to pursue research, realizing that being active in research makes them more effective in the classroom. Since the majority of students do not attend major research universities, these start-up awards should be open to new Ph.D.s at all colleges and universities.

E. Provide researchers and educators with access to the most advanced tools, facilities, and cyberinfrastructure.

The development and availability of new tools has opened vast research frontiers and fueled technological innovation in fields as broad as biotechnology, imaging for health and medicine, nanotechnology and communications. A recent NSB study[10] analyzed and identified requirements for investment in future infrastructure capability.

The study found that, over the past decade, funding for academic research infrastructure has not kept pace with rapidly changing technology, expanding research opportunities, and the increasing numbers of users. Moreover, many urgent research questions can be answered only through the use of new generations of powerful technological tools. These new tools will make scientists and engineers more productive, as well as capable of undertaking more complex tasks and research problems.

[10] *Science and Engineering Infrastructure Report for the 21st Century-The Role of the National Science Foundation,* February 2003, NSB 02-190

The study concluded that the fractional investment of the NSF budget in S&E infrastructure must be increased. In addition, it identified the following priorities for additional investments in infrastructure through future growth of the NSF budget:

- *Instrument Technology Research:* This research accelerates the development of instrument technology to ensure that future research instruments and tools are capable of meeting the research challenges for the future.

- *Midsize Infrastructure***:** There is a growing list of high priority but unfunded midsize infrastructure (costing more than a few millions, but less than the scale of MREFC projects) that will address some of the most compelling problems in science. Just a few examples of such midsize facility needs include: petawatt lasers for Physics/Astronomy; a relocatable atmospheric observatory for Geoscience; databases for long-term tracking of students for Education; and nanotechnology experimentation and test facilities for Engineering.

- *Large Facility Projects:* The ability to develop and construct new large research facilities is critical to sustaining U.S. leadership in key S&E fields. Furthermore, most major facilities supported by NSF have the capability to transform S&E fields by altering fundamental scientific concepts and changing the way research problems are addressed. Several large facility proposals have been approved for funding by the NSB, but have not yet been funded. Increased funding is needed to meet the need for new projects and address the backlog of NSB approved projects.

- *Cyberinfrastructure:* A significant additional investment in widely shared cyberinfrastructure is needed to bring next generation computer, networking, and database and sensor capabilities to researchers and students nationwide. This investment should provide high-quality, secure cyberinfrastructure, including both leading-edge and moderate-cost computation, storage, analysis, visualization, and communication, to enable researchers to explore new experimental vistas, and collaborate more broadly and effectively. This important undertaking, which requires a significant investment in software and technical staff, as well as hardware, will play a critical role in creating tomorrow's research vistas.

- *Education and Training Opportunities*: Educating people to understand how S&E instruments and facilities work and how they uniquely contribute to knowledge in their targeted disciplines is critical. There are also opportunities to expand access to state-of-the-art S&E infrastructure to faculty and students at primarily undergraduate colleges and universities.

The FY 2004 Budget to Congress requests $1.34 billion for Tools. The Board estimates that it will require additional funding of at least $2 billion per year to meet the needs identified in the infrastructure report and maintain U.S. leadership in science and engineering.

F. Maintain NSF's Excellence in Management

The pace of discovery is accelerating, creating exceptional opportunities for discovery, and also increasing the NSF workload. The number of proposals NSF processes exceeds 40,000, up from 35,000 a year ago and 30,000 just two years ago. The rapidly changing character of research has placed new demands on NSF staff and systems. These proposals address more complex scientific questions; involve a wider variety of collaborations, and often cross disciplinary and organizational boundaries. These added factors naturally require more monitoring and oversight.

Almost ninety-five percent of the federal funds NSF receives goes to education and research institutions and contractors. NSF spends only about five percent of its budget on administration and management. Funding for the agency has grown significantly in the past decade, while the agency's staffing level has remained flat. Excellence in managing NSF depends on maintaining a diverse, agile, results-oriented NSF workforce that operates in a continuous learning environment.

NSF has identified 150 new positions that it needs to relieve growing workload pressures on current NSF program managers and to provide increased attention to award management and oversight. The Board concurs with and supports this need. Furthermore, as the NSF budget grows, there should be commensurate growth in funding for personnel and administration support.

III. NSB RECOMMENDATIONS

The funding levels provided for in the Authorization Act increase NSF's annual budget from the FY 2004 Request of $5.5 billion to $9.8 billion in FY 2007. Section 22 specifically asks the Board to provide recommendations on how the increased funding should be used. The Board recommends that this $4.3 billion budget increase be used for the priorities described below. In developing these recommendations, the Board decided to address the unmet needs and opportunities discussed in Section II, rather than spread the increases across all of the Foundations programs and activities.

The National Science Board recommends the following increases in funding:

$1.0 billion to improve the productivity of researchers and expand opportunities for students. This additional funding will enable NSF to increase the average annualized research grant from a goal of $128K in FY 2004 to $163K in FY 2007 and increase the average grant duration from 3.0 to 3.5 years. This action will enable thousands of the nation's top researchers to pursue more complex and innovative research while spending less time preparing government paperwork. It will also significantly expand opportunities for students – increasing both the numbers of students supported and the stipends they receive – and thereby help attract and retain top talent for the U.S. S&E workforce.

$1.0 billion to open new frontiers in research and education. Specifically, this funding would be used to:

- Support as many as 1,500 meritorious proposals that are declined each year because of the lack of funds, thereby enabling NSF to address many research opportunities that are currently missed.
- Establish an Innovation Fund to enable the Foundation to more rapidly explore and initiate new frontiers in research and education.
- Expand NSF's Small Grants for Exploratory Research (SGER) mechanism to support substantially more untested and novel ideas and ventures into emerging research areas.
- Increase support for priority research areas to provide leadership in frontier S&E areas of national importance.

$0.7 billion to help build a diverse, competitive and globally-engaged S&E workforce. Specifically, this funding would be used to:

- Enhance NSF's undergraduate and graduate student programs, increasing both the numbers of students supported and the amount of support (stipend) received.
- Expand the Robert Noyce Scholarships, the STEM Talent Expansion program, and the Math and Science Partnerships.
- Increase support for international collaboration in S&E research and education, particularly by younger scientists and engineers.
- Support additional research that enhances understanding of learning and teaching at the K-12 and undergraduate level.
- To substantially increase the investment in research on workforce dynamics; and lead a national effort to build a base of information on the current the S&E workforce.

$0.2 billion to increase the number and diversity of institutions of higher education that participate in NSF-funded activities. Specifically, this funding would be used to:

- Increase the number of schools participating in the Robert Noyce Scholarships.
- Develop a new program for institutions that will identify best practices in attracting, sustaining, retaining, and graduating U.S. students from under-represented groups, and invest in those institutions that demonstrate this skill.
- Enable faculty and students at smaller universities and colleges to engage in research and other professional development activities.
- Provide start-up awards for new Ph.D.

$1.2 billion to provide scientists and engineers with advanced tools, facilities, and cyberinfrastructure. Specifically, this funding would be used to:

- Develop a widely shared cyberinfrastructure that will bring next generation computer, networking, and database and sensor capabilities to institutions, researchers and students nationwide.
- Initiate new major research facility projects that are critical to U.S. leadership in key S&E fields and address the backlog of NSB approved facility projects.
- Address the need for *midsize research infrastructure,* costing more than a few millions, but less than the scale of MREFC projects.

- Increase *Major Research Instrumentation* by $50 million to address multi-user instrumentation needs in all research and education areas and expand support to undergraduate institutions and minority-serving institutions.
- Increase research to advance the development of instrument technology to ensure that future research instruments and tools will meet future research challenges.

$0.2 billion to maintain NSF's excellence in management. This additional funding should be used to strengthen NSF's management of the investment process and operations. This should include strengthening the NSF workforce, enhancing the information technology infrastructure, promoting leading-edge approaches to eGovernment, and ensuring adequate safety and security across all of NSF's information technology and physical resources.

The Board's recommendations for the FY 2007 authorized funding levels are summarized in the following table, compared to the FY 2004 budget request and the total unmet needs discussed in Section II.

NSB RECOMMENDATIONS IN CONTEXT

	$ Billions (Current Dollars)		
Unmet Needs and Opportunities	**FY 2004 Request**	**FY 2007 Congress Authorized**	**Verified Total Need**
Improve Researcher Productivity (increase award size and duration)	2.7	3.7	8.7
Open New S&E Frontiers	--	1.0	2.0
Build S&E Workforce	1.2	1.9	3.2
Expand Institutional Base	--	0.2	0.5
Provide Advanced Infrastructure	1.3	2.5	3.3
Maintain Management Excellence	.3	0.5	1.0
Total	**$ 5.5**	**$ 9.8**	**$ 18.7**

IV. CONCLUSION

The NSF Authorization Act of 2002 reflects faith and confidence in the nation's academic S&E enterprise, which time and again has delivered returns to society that are among the highest of any government investment. The Act increases NSF's annual budget authority from the FY 2004 request of $5.5 billion to $9.8 billion in FY 2007. If

these funds are appropriated, a very significant initial step will have been taken towards fully enabling the S&E community.

But to address full extent of the research and education needs that are not being met, the Board believes that NSF budget must be increased to almost $19 billion, nearly double the level authorized by Congress. This will finally bring the federal investment in basic research and education to a level that will sustain future U.S. leadership in science and technology. It will enable the U.S. to develop the talented people, make the discoveries, and provide the cutting-edge tools needed to secure the nation's future prosperity, and well-being. It will also provide advances in science and technology that will be needed to prevent and counter potential future threats and attacks to the U.S. homeland.

In response to Congress, the Board provided specific recommendations on how the increased funding provided by the Authorization Act should be used. To ensure the most productive use of the funding, the Board's recommendations addressed a number of unmet needs and strategic opportunities, rather than spreading the increases across all of the Foundations programs and activities.

In the 21st century, nothing will be as important to our nation's prospects as the ability to create and make use of knowledge. It is vital that the U.S. maintain international leadership in key science and engineering fields. More than anything else, this will depend on the quality of the nation's S&E workforce. Using its hallmark strategy of integrating research and education, NSF is able to employ its total resources to this effort. The funding recommendations provided by the Board are designed to strengthen and exploit this synergy. And in the process of developing the talented scientists and engineers of the future, there will be remarkable opportunities to advance the frontiers of knowledge and the welfare of society.

> *The pioneer spirit is still vigorous within this nation. Science offers a largely unexplored hinterland for the pioneer who has the tools for his task. The rewards of such exploration both for the Nation and the individual are great. Scientific progress is one essential key to our security as a nation, to our better health, to more jobs, to a higher standard of living, and to our cultural progress.*
>
> Vannevar Bush, 1945

APPENDIX A

AMOUNTS AUTHORIZED IN NSF AUTHORIZATION ACT OF 2002, P.L. 107-368

	Dollars in Millions				
Appropriation Account	**FY 2004 Request**	**FY 2004 Auth.**	**FY 2005 Auth.**	**FY 2006 Auth.**	**FY 2007 Auth.**
Research and Related Activities	4,106	4,800	5,544		
Information technology	*695*	*774*			
Nanotechnology	*249*	*350*			
Education and Human Resources	938	1,157	1,331		
Math & Science Partnerships	*200*	*300*	*400*		
Robert Noyce Scholarships	*4*	*20*	*20*		
Technology Talent	*7*	*30*	*35*		
Major Research Equipment and Facilities Construction	202	211	259		
Salaries & Expenses	226	210	231		
National Science Board		4	4		
Office of the Inspector General	9	8	9		
Total[a]	$5,481	$6,391	$7,378	$8,520	$9,839

[a] Numbers may not add due to rounding.

APPENDIX B

NSF Authorization Act of 2002, P.L. 107-368, Section 22
Report on Foundation Budgetary and Programmatic Expansion.

The Board shall prepare a report to address and examine the Foundation's budgetary and programmatic growth provided for by this Act. The report shall be submitted to the Committee on Science of the House of Representatives, the Committee on Commerce, Science, and Transportation of the Senate, and the Committee on Health, Education, Labor, and Pensions of the Senate within one year after the date of the enactment of this Act and shall include –

(1) recommendations on how the increased funding should be utilized;

(2) an examination of the projected impact that the budgetary increases will have on the Nation's scientific and technological workforce;

(3) a description of new or expanded programs that will enable institutions of higher education to expand their participation in Foundation-funded activities;

(4) an estimate of the national scientific and technological research infrastructure needed to adequately support the Foundation's increased funding and additional programs; and

(5) a description of the impact the budgetary increases provided under this Act will have on the size and duration of grants awarded by the Foundation.

APPENDIX C

RELEVANT NATIONAL SCIENCE BOARD REPORTS

The following NSB reports have been cited in this report and are available at the following NSB website: *http://nsf.gov/nsb/documents/reports.htm*

1. *Environmental Science and Engineering for the 21st Century: The Role of the National Science Foundation*, Feb. 2000, NSB 00-22
2. *The Science and Engineering Workforce - Realizing America's Potential*, August 14, 2003, NSB 03-69
3. *Toward a More Effective Role for the U.S. Government in International Science and Engineering*, NSB 02-01
4. *Science and Engineering Infrastructure Report for the 21st Century-The Role of the National Science Foundation,* February 2003, NSB 02-190